TECHNICAL SPECIFICATION

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Particulate air filters for general ventilation — Determination of filtration performance

Filtres à air particulaires pour ventilation générale — Détermination des performances de filtration

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

- an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;
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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 21220 was prepared by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*.

Introduction

This Technical Specification is based on EN 779[5] and ANSI/ASHRAE 52.2[1], and covers the testing of the performance of air filters mainly used in general ventilation applications. During its preparation, it was perceived that the document was not sufficiently mature for publication as an International Standard, and so its publication as a Technical Specification was decided as an intermediate step. Moreover, with such a document covering the needs of the air filtration industry and of the end users, it is envisaged that a future revision in the form of an International Standard could also include a classification system.

The classification or rating of air filters is determined by national bodies or other associations and is not within the scope of this Technical Specification

In the method set out in this Technical Specification, representative samples of particles upstream and downstream of the filters are analysed by an optical particle counter (OPC) to provide filter particle size efficiency data.

Initiatives to address the potential problems of particle re-entrainment, shedding and the in-service charge neutralization characteristics of certain types of media are presented.

Certain types of filter media rely on electrostatic effects to achieve high efficiencies at low resistance to air flow. Exposure to some types of challenge, such as combustion particles or other fine particles, can inhibit such charges, with the result that filter performance suffers. The conditioning test procedure given in Annex A provides techniques for identifying this type of behaviour and can be used both to determine whether the filter efficiency is dependent on the electrostatic removal mechanism and to provide quantitative information about the importance of the electrostatic removal. This procedure was selected because it is well established, reproducible, simple to perform and relatively quick and ultimately because an acceptable alternative procedure was not available.

In an ideal filtration process, each particle would be permanently arrested at the first contact with a filter fibre, but incoming particles can impact on a captured particle and dislodge it into the air stream. Fibres or particles from the filter itself could also be released, due to mechanical forces. From the user’s point of view it might be important to know this, and a description is given in Annex B.

A brief overview of the test method and its principles is given in Annex C.

A means for calculating pressure drop is set out in Annex D.

TECHNICAL SPECIFICATION **ISO/TS 21220:2009(E)**

Particulate air filters for general ventilation — Determination of filtration performance

1 Scope

This Technical Specification presents test methods and specifies a test rig for measuring the filter performance of particulate air filters used for general ventilation. The test rig is designed for an air flow rate of between 0,25 m^3/s [900 m^3/h (530 ft^3/min)] and 1,5 m^3/s [5 400 m^3/h (3 178 ft^3/min)].

This Technical Specification is applicable to air filters having an initial efficiency of less than 99 % with respect to 0,4 µm particles. Filters in the higher end and those with an above 99 % initial efficiency are tested and classified according to other standards.

It combines two test methods: a “fine” method for air filters in the higher efficiency range and a “coarse” method for filters of lower efficiency. In either case, a flat-sheet media sample or media pack sample from an identical filter is conditioned (discharged) to provide information about the intensity of the electrostatic removal mechanism. After determination of its initial efficiency, the untreated filter is loaded with synthetic dust in a single step until its final test pressure drop is reached. Information on the loaded performance of the filter is then obtained.

The performance results thus obtained cannot alone be quantitatively applied to predict in-service performance with regard to efficiency and lifetime, so other factors influencing performance are presented in Annexes A and B.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2854, *Statistical interpretation of data — Techniques of estimation and tests relating to means and variances*

ISO 5167-1:2003, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

ISO 12103-1:1997, *Road vehicles — Test dust for filter* evaluation *— Part 1: Arizona test dust*

ISO 21501-1, *Determination of particle size distribution — Single particle light interaction methods — Part 1: Light scattering aerosol spectrometer*

ISO 21501-4, *Determination of particle size distribution — Single particle light interaction methods — Part 4: Light scattering airborne particle counter for clean spaces*

JIS Z 8901:1995, Test powders and test particles[1]

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[1] Japanese Industrial Standard.

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the following terms, definitions, symbols and abbreviated terms apply.

3.1
arrestance
A
weighted (mass) removal of loading dust by a filter

NOTE It is expressed as the percentage of the dust captured by the filter in terms of the mass of the total dust fed into it.

3.2
average arrestance
A_m
ratio of the total amount of loading dust retained by the filter to the total amount of dust fed up to the final test pressure drop

3.3
charged filter
filter in which the filter media is electrostatically charged or polarized

3.4
conditioned efficiency
efficiency of the conditioned filter media operating at an average media velocity corresponding to the test air flow rate in the filter

3.5
counting rate
number of counting events per unit of time

3.6
correlation ratio
ratio of downstream to upstream particle counts without the test filter in the test duct

3.7
DEHS
DiEthylHexylSebacate
liquid used for generating the DEHS test aerosol

3.8
dust loaded efficiency
efficiency of the filter operating at test flow rate and after dust loadings up to the final test pressure drops

3.9
effective filtering area
area of filter medium in the filter which collects dust

3.10
filter face area
frontal face area of the filter including the header frame

NOTE Nominal values: 0,61 m × 0,61 m (24 in × 24 in).

3.11
filter face velocity
air flow rate divided by the filter face area

3.12
final filter
air filter used to collect the loading dust passing through or shedding from the filter under test

3.13
final test pressure drop
pressure drop of the filter up to which the filtration performance is measured

3.14
initial efficiency
efficiency of the clean untreated filter operating at the test air flow rate

3.15
initial pressure drop
pressure drop of the clean filter operating at the test air flow rate

3.16
isokinetic sampling
sampling of the air within a duct such that the probe inlet air velocity is the same as the velocity in the duct at the sampling point

3.17
KCl
solid potassium chloride (KCl) particles generated from an aqueous solution and used as a test aerosol

3.18
loading dust
synthetic test dust
test dust specifically formulated for loading of the filter

NOTE Two types of loading dusts are used: ISO 12103-A fine test dust is used for the loading of filters according to the fine dust method and ASHRAE dust is used for the filters tested according to the coarse method.

3.19
mean diameter
geometric mean of the upper and lower border diameters in a size range

3.20
media velocity
air flow rate divided by the effective filtering area

NOTE It is expressed to an accuracy of three significant figures.

3.21
minimum efficiency
lowest efficiency of initial, conditioned or dust loaded efficiencies

3.22
neutralization
process by which the aerosol is brought to a Boltzmann charge equilibrium distribution with bipolar ions

3.23
particle bounce
behaviour of particles that impinge on the filter without being retained

3.24
particle size
equivalent optical diameter of a particle

3.25
particle number concentration
number of particles per unit volume of the test air

3.26
penetration
ratio of the particle concentration downstream to upstream of the filter

3.27
recommended final pressure drop
maximum operating pressure drop of the filter as recommended by the manufacturer at rated air flow

3.28
re-entrainment
release to the air flow of particles previously collected on the filter

3.29
shedding
release to the air flow of particles due to particle bounce and re-entrainment as well as the release of fibres or particulate matter from the filter or filtering material

3.30
test air flow rate
volumetric rate of air flow through the filter under test

3.31
test aerosol
aerosol used for determining the efficiency of the filter

3.32
test dust capacity
TDC
dust holding capacity (deprecated)
DHC (deprecated)
amount of loading dust kept by the filter at the final test pressure drop

A	Arrestance, %
A_m	Average arrestance during test to final test pressure drop, %
CL	Concentration limits of particle counter
C_V	Coefficient of variation
$C_{\mathrm{V},i}$	Coefficient of variation in size range i
$C_{\mathrm{mean},i}$	Mean of measuring points value for size range i
DEHS	DiEthylHexylSebacate
d_i	Geometric mean of size range i, µm
d_l	Lower border diameter in a size range, µm
d_u	Upper border diameter in a size range, µm
$\overline{E}_i$	Average efficiency in size range i
m	Mass passing filter, g
m_d	Mass of dust downstream of the test filter, g
m_tot	Cumulative mass of dust fed to filter, g
m_1	Mass of final filter before dust increment, g

m_2	Mass of final filter after dust increment, g
N	Number of points
N_d	Number of particles downstream of the filter
$N_{\text{d},i}$	Number of particles in size range i downstream of the filter
$\overline{N_\text{d}}$	Average number of particles downstream of the filter
N_u	Number of particles upstream of the filter
$N_{\text{u},i}$	Number of particles in size range i upstream of the filter
$\overline{N_\text{u}}$	Average number of particles upstream of the filter
n	Exponent
OPC	Optical particle counter
p	Pressure, Pa (in WG)[2]
p_a	Absolute air pressure upstream of filter, kPa (in WG)
p_sf	Air flow meter static pressure, kPa (lb/in^2)
q_m	Mass flow rate at air flow meter, kg/s (lb/s)
q_V	Air flow rate at filter, m^3/s (ft^3/min)
R	Correlation ratio
R_i	Correlation ratio for size range i
T	Temperature upstream of filter, °C (°F)
T_f	Temperature at air flow meter, °C (°F)
TDC	Test dust capacity, g [formerly dust holding capacity (DHC)]
$t_{\left(1-\frac{\alpha}{2}\right)}$	Distribution variable
U	Uncertainty, % units
v_mean	Mean value of velocity, m/s (ft/min)
δ	Standard deviation
ν	Number of degrees of freedom
ρ	Air density, kg/m^3 (lb/ft^3)
φ	Relative humidity upstream of filter, %
Δm	Dust increment, g
Δm_ff	Mass gain of final filter, g
Δp	Filter pressure drop, Pa (in WG)
Δp_f	Air flow meter differential pressure, Pa (in WG)
$\Delta p_{1,20}$	Filter pressure drop at air density 1,20 kg/m^3, Pa (in WG)

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[2] Water inch gauge (non-SI unit).

4 Filter

The filter shall be designed or marked so as to prevent incorrect mounting. It shall be designed so that when correctly mounted in the ventilation duct, no air/dust leaks occur around the exterior filter frame or duct sealing surfaces.

The complete filter (filter and frame) shall be made of materials suitable for withstanding normal usage and exposure to the range of temperature, humidity and corrosive environments likely to be encountered in service.

The complete filter shall be designed to withstand mechanical constraints that are likely to be encountered during normal use. Dust or fibre released from the filter media by air flow through the filter shall not constitute a hazard or nuisance for people or devices exposed to filtered air.

5 Classification/rating

Filters are not classified or rated by this Technical Specification. Many national bodies and associations use 0,944 m^3/s (2 000 ft^3/min or 3 400 m^3/h) as the nominal air flow for classification or rating of air filters that are a nominal 0,61 m × 0,61 m (24 in × 24 in) in face area. It is therefore recommended that filters be tested at 0,944 m^3/s (if the manufacturer does not specify any other flow for another application). The air flow velocity associated with the volumetric flow is 2,54 m/s (500 ft/min).

6 Test rig and equipment

6.1 Test conditions

Either room air or outdoor air may be used as the test air source. Relative humidity shall be less than 65 % for the KCl efficiency measurement and less than 75 % in the other tests. The exhaust flow may be discharged outdoors, indoors or recirculated.

NOTE Requirements on certain measuring equipment can impose limits on the temperature of the test air.

Filtration of the exhaust flow is recommended when test aerosol, loading dust or odours from the filter can be present.

6.2 Test rig

The test rig (see Figure 1) shall consist of several square duct sections with 610 mm × 610 mm (24 in × 24 in) nominal inner dimensions except for the section where the filter is installed. This section shall have nominal inner dimensions between 616 mm (24,25 in) and 622 mm (24,50 in). The length of this duct section shall be at least 1,1 times the length of the filter, with a minimum length of 1 m (39,4 in).

The duct material shall be electrically conductive and electrically grounded, and shall have a smooth interior finish and be sufficiently rigid to maintain its shape at the operating pressure. Smaller parts of the test duct could be made in glass or plastic in order to make the filter and equipment visible. Provision of windows to allow monitoring of test progress is desirable.

High-efficiency filters shall be placed upstream of section 1, as indicated in Figure 1, in which the aerosol for efficiency testing is dispersed and mixed to create a uniform concentration upstream of the filter.

Section 2 includes in the upstream section the mixing orifice (3) in the centre of which the dust feeder discharge nozzle is located. Downstream of the dust feeder is a perforated plate (11) intended to achieve a uniform dust distribution. In the last third of this duct section is the upstream aerosol sample head. For dust loading tests, this sampling head shall be blanked off or removed.

To avoid turbulence, the mixing orifice and the perforated plate should be removed during the efficiency test. To avoid systematic error, removal of these items during pressure drop measurements is recommended.

Section 5 may be used for both efficiency and dust loading measurements and is fitted with a final filter for the loading test and with the downstream sampling head for the efficiency test. Section 5 could also be duplicated, allowing one part to be used for the loading test and the other for the efficiency test.

The test rig can be operated in either a negative or positive pressure air flow arrangement. In the case of positive pressure operation (i.e. the fan upstream of the test rig), the test aerosol and loading dust could leak into the laboratory, while at negative pressure particles could leak into the test system and affect the number of measured particles. These possible air leaks shall be located and sealed prior to filter testing.

The dimensions of the test rig and the position of the pressure taps are shown in Figure 2. Additional duct details are shown in Figure 3.

The pressure drop of the tested filter shall be measured using static pressure taps located as shown in Figure 3. Pressure taps shall be provided at four points over the periphery of the duct and connected together by a ring line.

The entry plenum and the relative location of high-efficiency filters and aerosol injections are discretionary and a bend in the duct is optional, thereby allowing both straight duct and U-shaped duct configurations. Except for the bend itself, all dimensions and components are the same for straight and U-shaped configurations. A downstream mixing baffle shall be included in the duct after the bend, whose purpose is to straighten out the flow and mix any aerosol that is downstream of the bend.

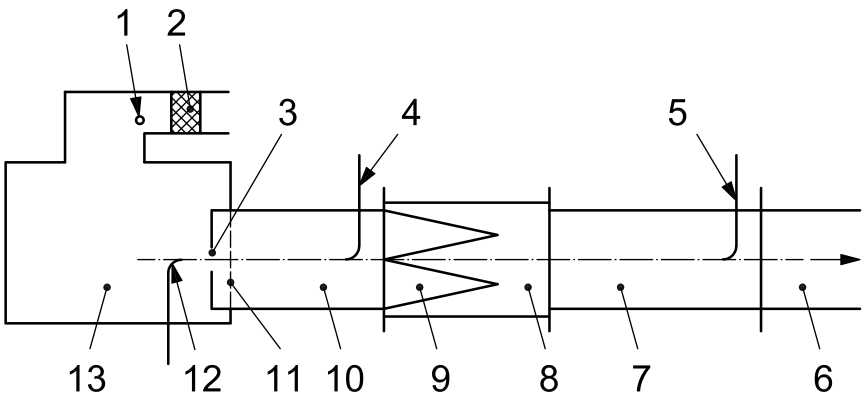
6.3 DEHS test aerosol generation

The test aerosol shall consist of untreated and undiluted DEHS, or other aerosols in accordance with 8.2. A test aerosol of DEHS (DiEthylHexylSebacate) produced by a Laskin nozzle aerosol generator is widely used in the performance testing of high-efficiency filters.

Figure 4 gives an example of a system for generating the aerosol. It consists of a small container with DEHS liquid and a Laskin nozzle. The aerosol is generated by feeding compressed particle-free air through the Laskin nozzle. The atomized droplets are then directly introduced into the test rig. The pressure and air flow to the nozzle are varied according to the test flow and the required aerosol concentration. For a test flow of 0,944 m^3/s (2 000 ft^3/min), the pressure is about 17 kPa (2,5 lb/in^2), corresponding to an air flow of about 0,39 dm^3/s [1,4 m^3/h (0,82 ft^3/min)] through the nozzle.

Any other generator capable of producing droplets in sufficient concentrations in the size range of 0,3 µm to 1,0 µm may be used.

Before testing, regulate the upstream concentration so as to reach steady state and obtain a concentration below the coincidence level of the particle counter.



Key

1	inlet point for DEHS particles
2	high-efficiency filter (at least 99,97 % on 0,3 µm particles)
3	mixing orifice
4	upstream sampling head
5	downstream sampling head
6	duct section of the test rig
7	duct section of the test rig
8	duct section including the filter to be tested
9	filter to be tested
10	duct section of the test rig
11	perforated plate
12	dust injection nozzle
13	duct section of the test rig (entry plenum)

Figure 1 — Test rig — Schematic diagram

Dimensions in millimetres

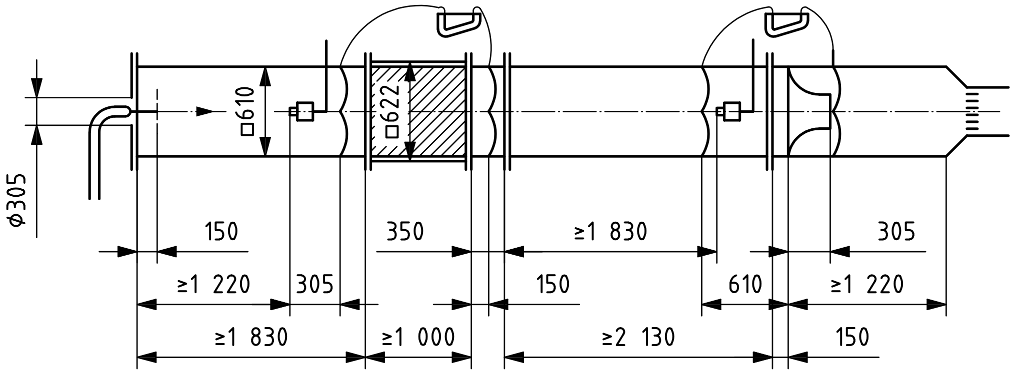
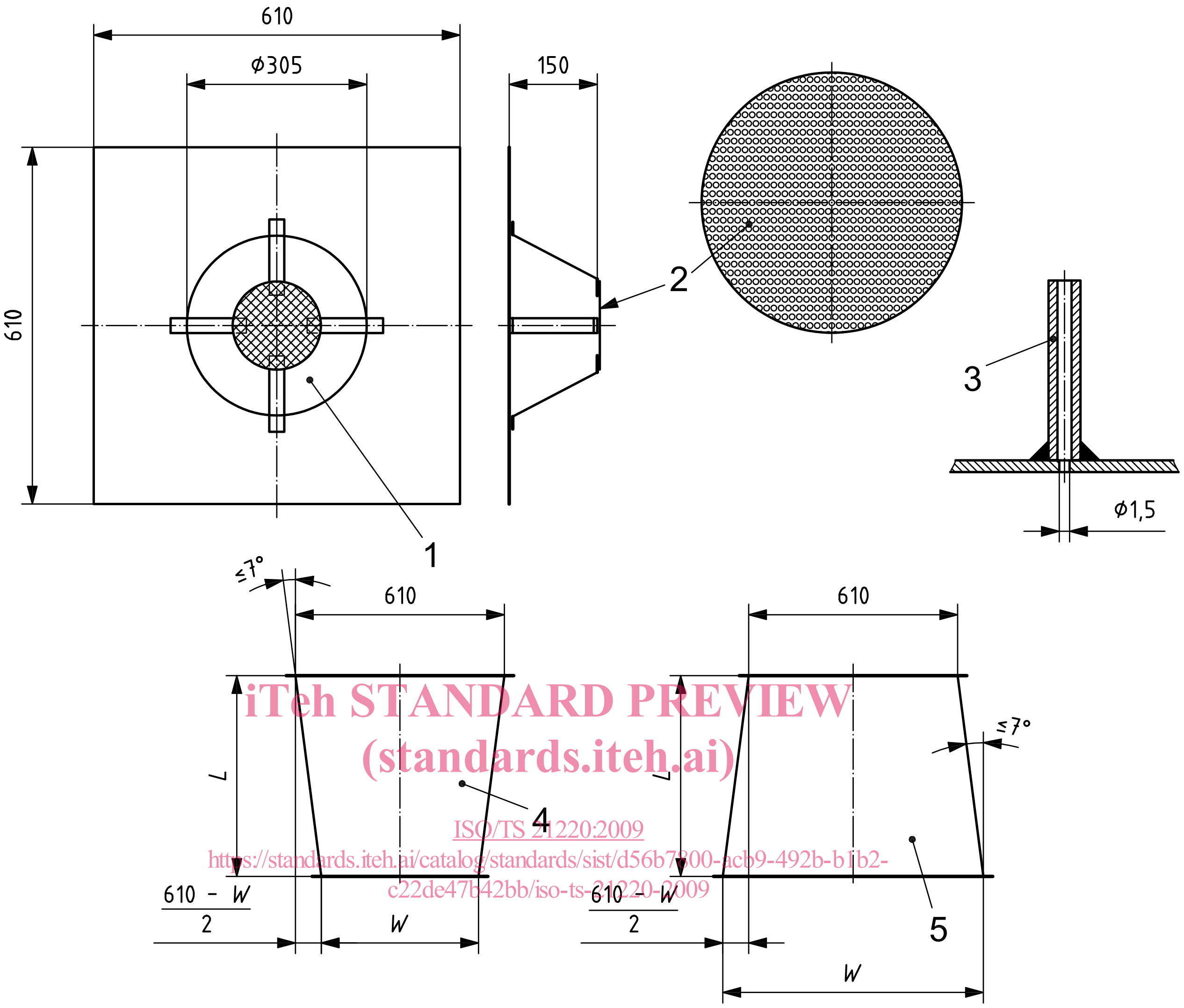


Figure 2 — Test rig dimensions

Dimensions in millimetres



Key

1	mixing orifice
2	perforated plate with ∅ (152 ± 2) mm and 40 % open area
3	pressure tap
4	transition duct — test filter smaller than duct
5	transition duct — test filter larger than duct
L	length
W	width

Figure 3 — Test duct component details